**Research background**

- **Surgical intervention against breast cancer**
  - Residual cancer cells
  - Breast defect

It is desirable to develop a method that can completely kill cancer cells and support breast reconstruction.

- **Injection of free nanoparticle against residual cancer cells**
  - 1. High intratumoral pressure
  - 2. EPR effect
  - 3. Non-specific distribution
  - 4. Easy to leak from tumor site

Scaffold is a promising novel platform for transporting nanoparticles with decreased systemic toxicities.

- **3D porous scaffold**

  - Cell-cell interaction
  - Nutrient diffusion
  - Waste transportation
  - Cell proliferation
  - 3D scaffolds are considered a platform for adipose tissue regeneration

**Previous studies**

- **Black phosphorus (BP) attractive properties**

**Photothermal**

- BP
- NIR
- Cancer cells

Huang Y et al., Chem. Mater. 2016, 28, 8330-8339

- After exposure to oxygen, the BP flake decomposed

- It remains unclear whether BP promotes adipose tissue regeneration

**Biodegradable**

- Freshly exfoliated BP
- After air exposure for 1 week

Kong N et al., Nano Letters. 2020, 20, 3943-3955

**Research objectives and methods**

- Prepare gelatin/BP porous scaffolds
- Investigate their effects on the breast cancer cells and human mesenchymal stem cells (hMSCs) for ablating cancer cells and promoting adipose tissue regeneration

**Characterization of scaffolds**

- SEM images
- Degradation profile

- All of the scaffolds had the high porous and well interconnected structure
- The gelatin matrix had protective effect against the degradation of BPNSs
- The addition of BP made the pore surface rougher

**Characterization of BP nanosheets (BPNSs)**

- Bulk BP
- Exfoliation
- BPNSs

- Requirements:
  1. Size ≤ 1 µm
  2. Single or few layers

- Average size 349 ± 129 nm
- Size more than 2 µm

- After exfoliation, there was a reduction both in size and number of layers

**Effects on breast cancer cells**

- Gelatin
- BP1-gelatin
- BP2-gelatin

- Type of cancer cells: MDA-MB231-Lac
- NIR irradiation: 805 nm
- Laser intensity of 2.0 W cm⁻²
- Irradiation time: 10 min

- With NIR laser irradiation lower irradiance
- With NIR laser irradiation higher irradiance

- Temperature change under NIR irradiation: BP2-gelatin > BP1-gelatin > gelatin
- Anticancer efficacy: BP2-gelatin > BP1-gelatin > gelatin

**Effects on adipogenic differentiation**

- Adipogenic medium
- 21 days
- Adipocyte

- Oil red O staining
- Quantification of lipid droplets in adipogenic medium

- Gelatin
- BP1-gelatin
- BP2-gelatin

- Significant difference: *p < 0.05; **p < 0.01; ***p < 0.001; N.S. = no significant difference. n = 3.

- Effects on adipogenic differentiation: BP2-gelatin > BP1-gelatin > gelatin

**Conclusions and future perspective**

- The composite scaffolds had a well-interconnected pore structure with the BPNSs homogenously distributed on the pore walls.
- The composite scaffold with a high amount of BPNSs could effectively kill breast cancer cells. Moreover, the composite scaffolds facilitated the adipogenic differentiation of hMSCs.
- The composite scaffolds are anticipated to serve as a platform for ablation against breast cancer cells and the reconstruction of adipose tissue.

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